Processes of alluvial sedimentation in the Eocene Hyalite Peak volcanics, Absaroka-Gallatin volcanic province, Southwest Montana
by Margaret M Hiza

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University


Abstract:
Eocene Hyalite Peak volcanics in the Gallatin Range, southwest Montana, consist of 1,800 m of sedimentary sequences and intercalated andesitic lava flows.

Lithofacies in the deposits, categorized based on texture, grain size, and fabric indicate that the processes of transport, grain support, and deposition of the sequences varied greatly. Sedimentary fabrics exhibit textures which record a broad continuum of flow transitions between streamflow, hyperconcentrated flow and debris flow processes produced by variation in the ratio of sediment to water. Variability in the amount of , clast-support and types of grading in Hyalite Peak sequences were produced primarily by coarse-grained debris flow, variable stages of non-cohesive transitional flow, and hyperconcentrated flow. Key features in volumetrically minor deposits contain depositional fabrics which indicate they were produced and transported directly by eruptive activity. Deposits produced from pyroclastic flows and surges contain a large component of pumice and glass shards produced as juvenile pyroclastic material. Other near-vent deposits contain volcanic bombs and agglutinate. Together, sedimentary sequences within the Hyalite Peak volcanics exhibit fabrics and textures commonly described as volcaniclastic deposits found in modem volcanic settings.

Utilizing recent improvements in knowledge of sedimentation in modern volcanic systems, well exposed sequences of Eocene Hyalite Peak volcaniclastic strata are described in detail, and the processes which induced their formation are for the first I time characterized. Features within these deposits suggest that volcanic activity was I phreatic or phreatomagmatic, induced by groundwater-magma interaction. The variation I of lithofacies types in Hyalite Peak sequences indicate that deposition was produced through a broad range of transitions between processes of eruption and sedimentation which took place on the flanks of stratovolcanoes and near small localized vent sources.
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Margaret M. Hiza

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Earth Sciences

MONTANA STATE UNIVERSITY
Bozeman Montana

November 1994

APPROVAL

of a thesis submitted by

Margaret M. Hiza

This thesis has been read by each member of the thesis committee and has been found to be sastisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

1-11-95
Date

James Schmitt
Chairperson, Graduate Committee

Approved for the Department of Earth Sciences

1-11-95
Date

Head, Department of Earth Sciences

Approved for the College of Graduate Studies

2/1/95
Date

Graduate Dean

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# ACKNOWLEDGEMENTS

I would like to extend my warmest thanks to the members of my committee, Jim Schmitt, Dave Lageson and Steve Custer for their help in editing this thesis, and for their continual support and encouragement. Research was partially funded by the Donald L. Smith memorial scholarship, the Geological Society of America, and the American Association of Petroleum Geologists, to whom I am grateful. Additional research funding was provided through a National Science Foundation Fellowship without which the completion of this thesis would have been impossible. I would also like to thank my children, Aidan, Robert, and Shondiin Redsteer, for their understanding and moral support.

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# ABSTRACT

Eocene Hyalite Peak volcanics in the Gallatin Range, southwest Montana, consist of 1,800 m of sedimentary sequences and intercalated andesitic lava flows. Lithofacies in the deposits, categorized based on texture, grain size, and fabric indicate that the processes of transport, grain support, and deposition of the sequences varied greatly. Sedimentary fabrics exhibit textures which record a broad continuum of flow transitions between streamflow, hyperconcentrated flow and debris flow processes produced by variation in the ratio of sediment to water. Variability in the amount of clast-support and types of grading in Hyalite Peak sequences were produced primarily by coarse-grained debris flow, variable stages of non-cohesive transitional flow, and hyperconcentrated flow. Key features in volumetrically minor deposits contain depositional fabrics which indicate they were produced and transported directly by eruptive activity. Deposits produced from pyroclastic flows and surges contain a large component of pumice and glass shards produced as juvenile pyroclastic material. Other near-vent deposits contain volcanic bombs and agglutinate. Together, sedimentary sequences within the Hyalite Peak volcanics exhibit fabrics and textures commonly described as volcaniclastic deposits found in modern volcanic settings.

Utilizing recent improvements in knowledge of sedimentation in modern volcanic systems, well exposed sequences of Eocene Hyalite Peak volcaniclastic strata are described in detail, and the processes which induced their formation are for the first time characterized. Features within these deposits suggest that volcanic activity was phreatic or phreatomagmatic, induced by groundwater-magma interaction. The variation of lithofacies types in Hyalite Peak sequences indicate that deposition was produced through a broad range of transitions between processes of eruption and sedimentation which took place on the flanks of stratovolcanoes and near small localized vent sources.

# INTRODUCTION

Processes of alluvial sedimentation in regions of active volcanism are unique and unparalleled: rapid mobilization of sediment and water occurs episodically and in large volumes. As a result, debris flow and hyperconcentrated flood flow deposits tend to be numerous and extensive (Smith, 1986). Since the eruption of Mount St. Helens in 1980, a wealth of information has been collected pertaining to mechanisms of sediment transport in modern volcanic terranes (Harrison and Fritz, 1982; Fisher and others, 1987; Pierson, 1985; Brantley and Waitt, 1988). Studies at Mount St. Helens, Mayon Volcano in the Phillipines, Nevado del Ruiz in Colombia, and in other modern volcanic settings demonstrate that volcanically produced sediment tends to be coarse-grained and far traveled (Pierson and Scott, 1985; Lowe and others, 1986; Pierson and others, 1990). Volcanically induced debris flows may lack the cohesion which has been generally accepted as the mechanism which imparts mobility to the large clasts found within their deposits (Scott, 1988; Walton and Palmer, 1988; Arguden and Rudolfo, 1990). Without cohesion, mobility and grain support result from dilatant flow, which is produced in part by dispersive pressure. During eruptive phases, pyroclastic flows and surges can mobilize large amounts of sediment, initiating catastrophic debris flows. Associated steam and hot air can impart mobility and decrease viscosity in the resulting sediment gravity flows (Arguden and Rodolfo, 1990). Flow transformations between these debris flows and hyperconcentrated flood flow are common occurrences (Pierson and Scott, 1985; Major and Scott, 1988). Factors such as these make processes of sedimentation within volcanic terranes incomparable to those of other fluvial systems.

Depositional processes characteristic of volcanic settings have not been accounted for in conventional fluvial facies models. Smith (1987) refined facies codes to include hyperconcentrated flood flow deposits which result from periods of high discharge common in volcanic settings, but which are also less frequently found in arid alluvial fan sequences. Other types of coarse-grained volcaniclastic deposits have been subdivided into separate facies by Fritz and Harrison (1985), Waresback and Turbeville (1990), Palmer and Walton (1990), and Borrero and Naranjo (1990), but are still described with general facies codes.

The purpose of this study is to utilize recent improvements in the knowledge of volcanically-influenced terrestrial sedimentation derived from modern systems to characterize the types of alluvial processes that were active in the Eocene Hyalite Peak Volcanics of the northern Gallatin Range, Montana. Consisting of predominantly andesitic lava flows, these strata also include a large volume of alluvial deposits. Even though the Hyalite Peak Volcanics are well exposed, stratigraphic sections have only been generally described by Chadwick (1969). Facies were defined based upon description of lithologic units within measured sections, and used to interpret processes of transportation, grain support, and deposition. Used to describe and interpret these deposits, it is hoped that they can be applied generally to volcaniclastic sequences found elsewhere. Vertical and lateral relations between facies were also examined in order to distinguish the types of depositional sequences present and to interpret sequences of events which may have occurred.

## Geologic Setting

Two belts of eruptive centers active during Eocene time are located in southwestern Montana and northwestern Wyoming. Chadwick (1970) named them the eastern and western Absaroka belts and distinguished them from each other by chemical whole rock analysis, noting that samples from eruptive centers of the eastern belt had higher $K_2O:SiO_2$ ratios. The resulting deposits, which are thought to have been emplaced on the flanks of stratovolcanoes, extend northwestward from the southeastern part of the Absaroka Range through the Gallatin Range (Figure 1). These volcanic and volcaniclastic rocks have been included within the Absaroka Volcanic Supergroup (Smedes and Prostka, 1972) which is divided stratigraphically into the Washburn, Sunlight, and Thorofare Creek Groups. The Absaroka Volcanic Supergroup is now considered part of the Absaroka-Gallatin volcanic province, indicating more clearly that the rocks extend beyond the Absaroka Range (Chadwick, 1970). The oldest and northernmost volcanic sequences are of the Washburn Group. Located in the Gallatin and Beartooth Ranges, the Washburn Group is characterized by near-vent lava flows, autoclastic flow breccias, mudflows, avalanche debris, and tuff deposits which grade laterally into and interfinger with well-bedded, reworked volcanic conglomerate, volcanic siltstone and sandstone, and ash-fall tuff (Smedes and Prostka, 1972).

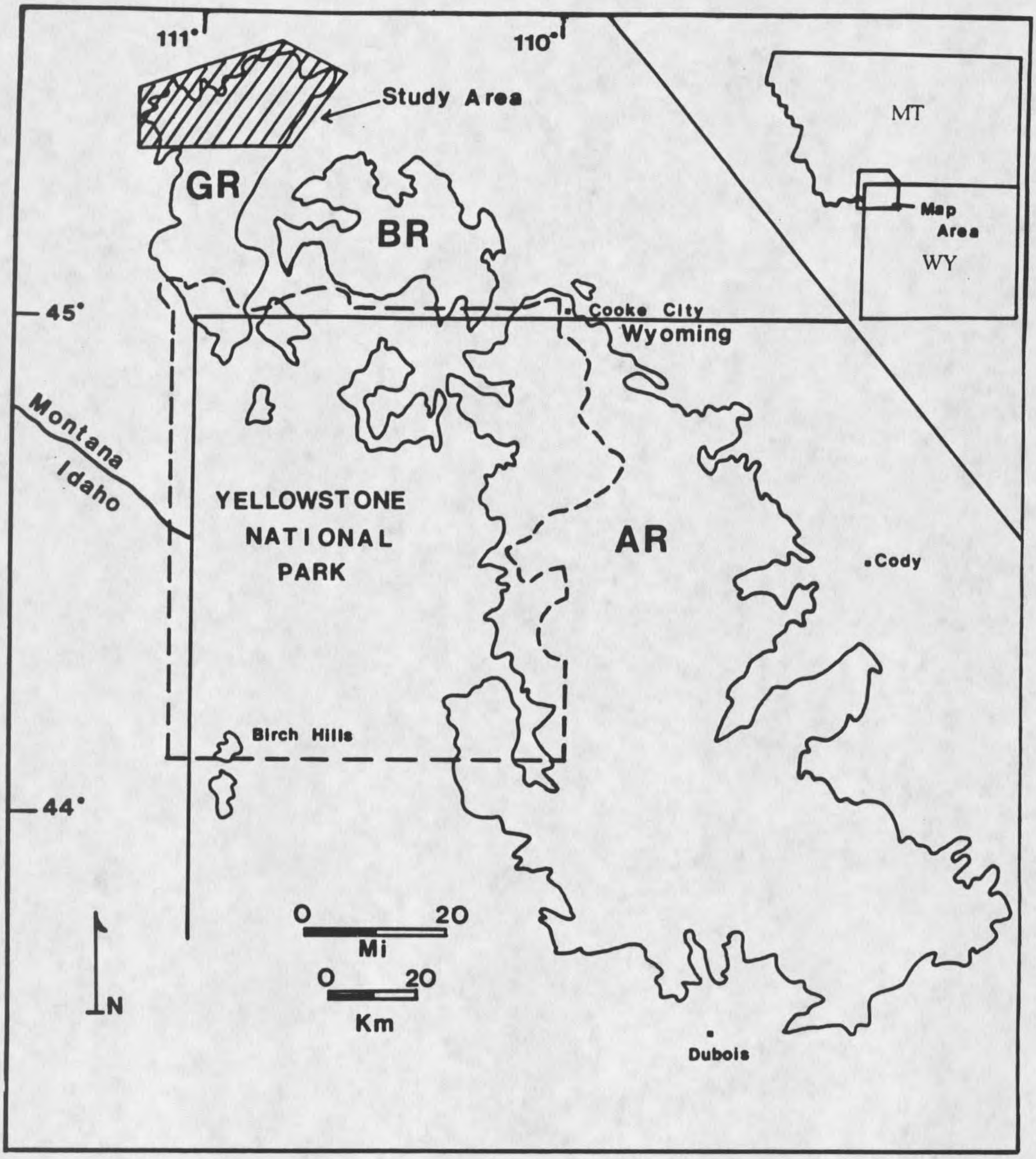


Figure 1. Generalized map with solid line showing the distribution of Eocene volcanic and volcaniclastic rocks belonging to the Absaroka-Gallatin volcanic province. Mountain ranges containing these deposits include the Absaroka Range (AR), the Gallatin Range (GR), and the Beartooth Range (BR). Location of the study area is shaded.

This study focuses on deposits within the northern Gallatin Range. Igneous centers in the northern Gallatin Range erupted predominantly andesitic lavas which have been intruded locally by dacite stocks and plugs. The Big Creek stock, a dacite intrusion which cuts across both northern volcanic sequences, has been dated at 49.5 ± 1.5 ma, by K/Ar whole rock analysis (U.S. Gelogical Survey, J.D. Obradovich, in Chadwick, 1969).

Initial Eocene volcanism in the Gallatin Range is recorded by the Golmeyer Creek Volcanics, a 600 m thick sequence of interbedded hypersthene-andesite flows and flow breccias and minor epiclastic sedimentary rocks which have no correlative units elsewhere (Smedes and Prostka, 1972). These deposits rest on top of an erosional surface developed on Archean metamorphic and igneous rocks. Early dacite intrusions are represented by clasts found within the Golmeyer Creek volcaniclastic units (Chadwick, 1969). Golmeyer Creek deposits were extensively eroded prior to the eruption of younger volcanics and pinch out to the northwest.

The Hyalite Peak Volcanics, which are widespread and unconformably overlie the Golmeyer Creek Volcanics, also in places rest directly on an irregular pre-Eocene topographic surface (Iddings and others, 1894; Peale, 1896; McMannis and Chadwick, 1964). Deformed Precambrian metamorphic rocks and folded Paleozoic and Mesozoic sedimentary beds impart an estimated 650 m of relief to the pre-volcanic topography (Chadwick, 1984). Eocene volcanic deposits filled in paleovalleys, but many units are subhorizontal, dipping 10 to 12° southeast due to regional tilting toward the Yellowstone River Valley (Figure 2). The Hyalite Peak volcanics consist of a 700 to 1100 m thick sequence of interbedded augite-hypersthene andesite flows and flow breccia which are interbedded and interfinger with volcaniclastic sequences. Lenses of a fluvial conglomerate containing well-rounded pre-Hyalite Peak clasts of Precambrian quartzite, Paleozoic and Mesozoic clasts, along with volcanic clasts from an unknown source are locally found at the base. Volcaniclastic intervals within the Hyalite Peak Volcanics have thicknesses from a few tens to hundreds of meters, and constitute approximately 40% of the unit as a whole. Sedimentary sequences at several locations contain upright, buried trees and stumps. Epiclastic deposits were described by Chadwick (1969) as being characterized by crude stratification with poor sorting and angular clasts, and containing boulders more than 2 m in diameter from unknown sources.

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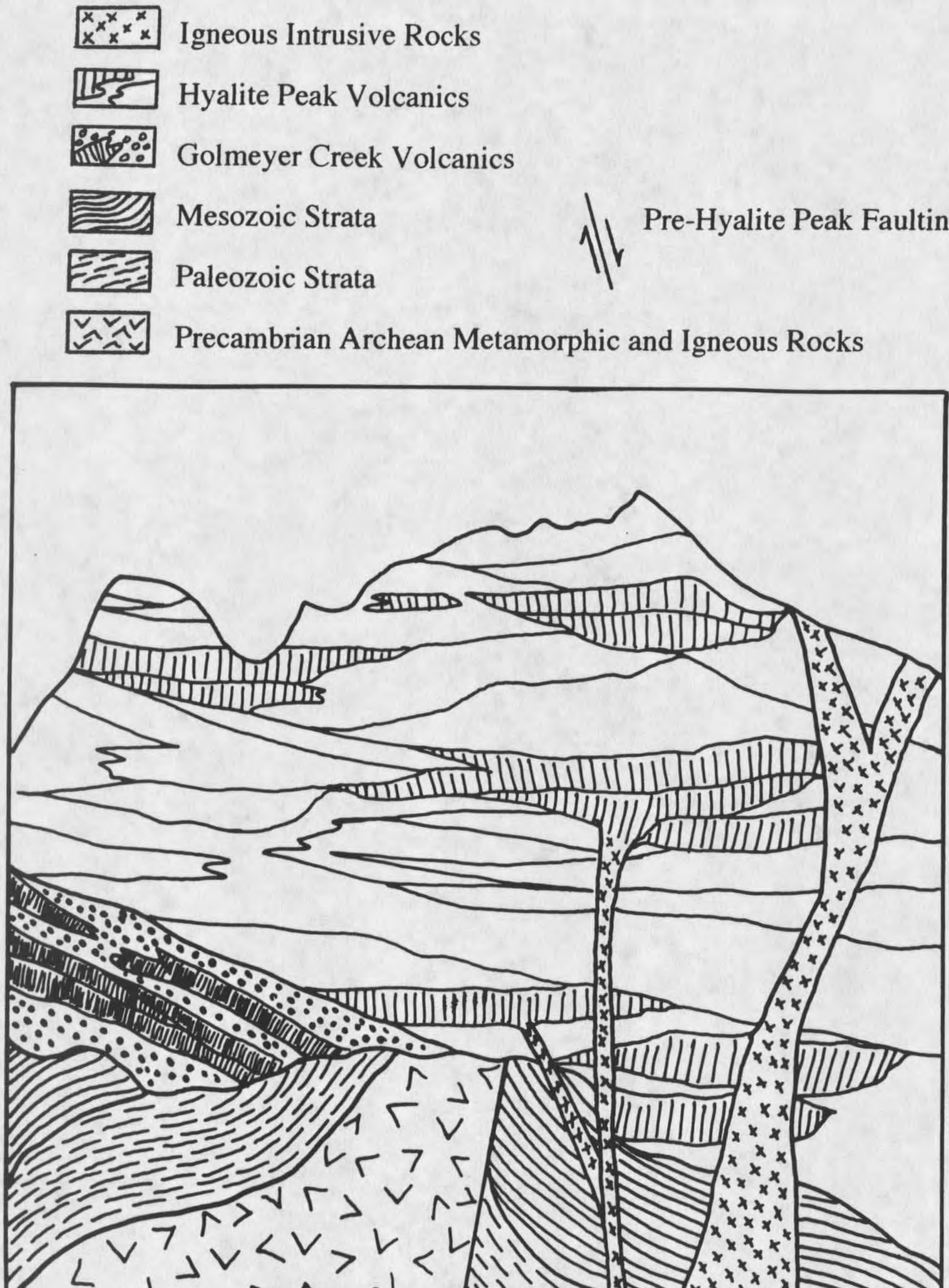


Figure 2. Schematic cross section showing stratigraphic relations in the northern Gallatin Range, southwest Montana. Actual thickness of the deposits is not represented.